

Diagnosing common gear-drive problems

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If your mechanical conveyor's gear drive is experiencing excess wear or premature gear failure but you aren't sure why, inspecting the gear-tooth wear patterns can help you diagnose the cause. This article lists some common symptoms of abnormal gear wear and provides general tips for how to solve gear-drive problems.

Mechanical conveying systems often use gear drives (also called gear reducers) to transmit power from the system's motor to the conveying mechanism (such as a belt or screw). A basic conveyor gear drive consists of two meshed gears: a smaller pinion gear attached to the motor shaft and a larger driven gear attached to the conveying mechanism. The gear drive reduces rotational speed and increases torque, while the meshed gear teeth prevent slippage.

Gear drives provide durable and reliable power transmission for mechanical conveyors (particularly low-speed, high-torque systems), but they do require regular maintenance. Always refer to your gear drive's installation and operating manuals for specific safety and maintenance instructions and follow all OSHA lockout/tagout procedures¹ prior to removing any guards, access doors, or covers. As a general guideline, you should check your gear drive's lubrication daily and set a schedule to inspect gears for wear or misalignment at 24 service hours after installation, at 100 service hours, at 500 service hours, and

then at least annually thereafter. Such periodic inspections, particularly in large units, can add many hours of service life to your gear drive. Often, you can detect abnormal wear in its preliminary stages and correct the problem before it leads to catastrophic gear-drive failure.

Identifying abnormal gear wear

Gear-tooth wear or breakage patterns can be very helpful in determining the cause of the wear or failure. When inspecting your gear drive, look carefully for a uniform wear pattern on the gear teeth, as shown in Figure 1a. Non-uniform or abnormal wear patterns typically indicate insufficient lubrication, misaligned gears, loading in excess of the gear drive's design, or abrasive contamination in the lubricating oil. The following are some common abnormal gear wear patterns and their causes.

Abrasive wear. Abrasive wear, as shown in Figure 1b, is often caused by small, hard particles from worn gear teeth or the surrounding environment contaminating the gear drive's lubricating oil. These particles scratch the gear teeth as the gears engage each other during operation. Maintaining clean, particle-free lubricating oil can help prevent abrasive wear. Follow these steps to remove abrasive contaminants from your gear drive's lubricating oil:

1. Drain the contaminated oil.
2. Thoroughly clean any residue from the gear housing's internal surfaces.
3. Clean and flush out any oil passages.
4. Refill the housing with a light, flushing-grade oil and run the gear drive without a load for 10 minutes.

5. Check the surrounding environment for possible contamination sources and cover or protect the gear drive as needed.
6. Drain the flushing oil and refill the drive with the recommended oil. In some instances, you may be able to clean the contaminated oil and reuse it.

Corrosive wear. Corrosive wear, as shown in Figure 1c, occurs when acid comes into contact with the gear teeth, causing a chemical reaction with the metal. Corrosive wear is usually identified by a stained or rusty appearance on the gear surface and can be caused by system overload or improper maintenance procedures. If your gear drive is showing corrosive wear, check with the drive supplier for the recommended maintenance procedures and lubricant type. You may need to perform more frequent oil changes or upgrade to an extreme-pressure lubricant. If the system is overloaded, you'll need to either reduce the load or upgrade the drive.

Electrical pitting. Electrical pitting, as shown in Figure 1d, can occur when electric discharges arc across the film of oil between mating gear teeth, causing small indentations to form on the tooth surface. These electric discharges can be caused by improper electrical system installation and grounding or static electricity generated by the conveying process. If your process is generating static electricity, install grounding straps from the conveyor to rigid electrical or pneumatic piping to dissipate the electrostatic charge. Also, when welding in the area, be sure to place the ground clamp so that the current doesn't flow through the gear drive and arc between the gear teeth.

Rolling and scuffing. Rolling (also called peening), as shown in Figure 1e, is the deformation of metal on the active portion of the gear tooth caused by high-contact stresses. This displacement of surface material creates horizontal grooves along the tooth face and causes burrs to form at the gear tooth's tip.

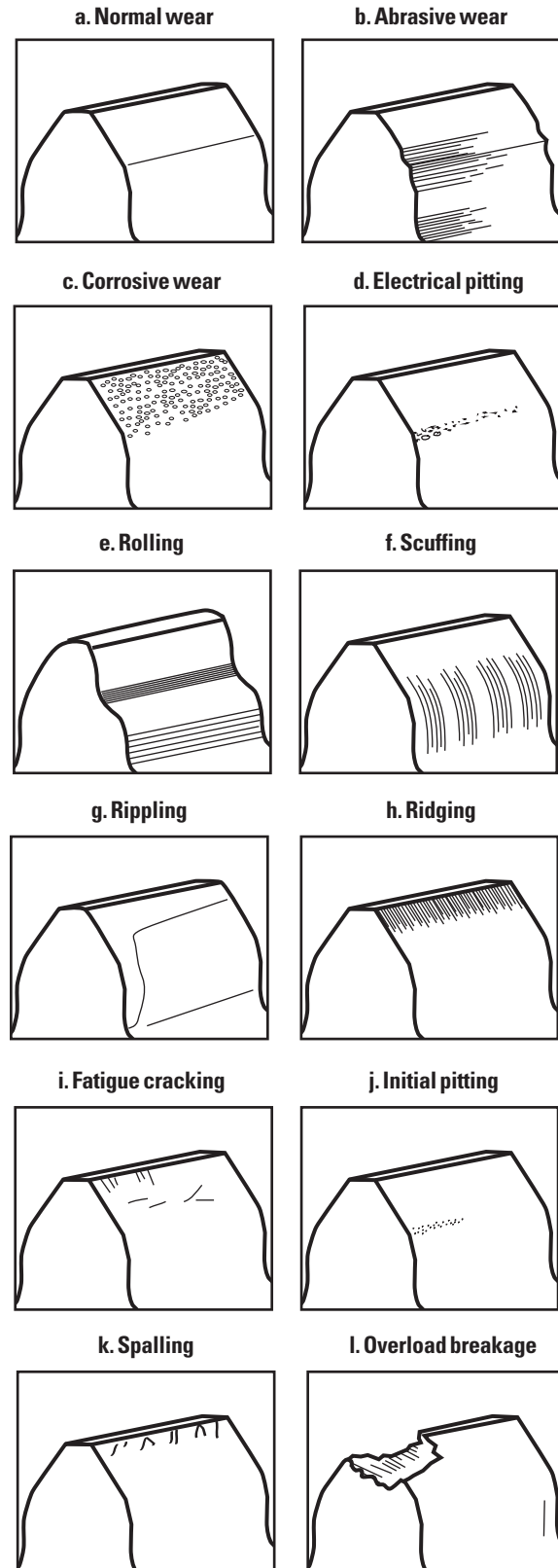
Scuffing is severe abrasion that causes metal from one gear tooth surface to transfer to another tooth due to welding and tearing action during operation. Scuffing can be identified by vertical lines on the tooth surface, as shown in Figure 1f. Scuffing is generally localized in patches where the meshed tooth surfaces are mismatched or misaligned.

Rolling and scuffing occur when gear teeth don't mesh properly and will continue until the damage is severe enough for the drive to fail. Rolling and scuffing can also be caused by improper *backlash*. Backlash is the clearance between engaged gear teeth that prevents the gears from binding during operation. If your gear drive isn't

reversible but the gear teeth are showing wear on both faces, the backlash is insufficient and needs to be reset.

Figure 1

Gear wear patterns



Plastic flow failure. Plastic flow failure (also called rippling or ridging), as shown in Figures 1g and 1h, is a type of deformation of the gear-tooth surface caused by high levels of sliding or rolling stress between mating gear teeth. Plastic flow failure typically affects gears made of softer metals but can also occur in case-hardened gears. Heavily loaded worm drives and hypoid-and-pinion gear drives, which combine high compressive stress with high-contact, low-velocity sliding action, are most-frequently affected. Plastic flow failure is typically caused by improper lubrication or excessive operating loads and can become dangerous in advanced stages.

Fatigue wear. Fatigue wear is created by repeated application of stress below the gear material's tensile strength. Fatigue wear begins the first moment a gear is used and can be exacerbated by thermal stress (temperature fluctuations) or material flaws in the gear. In a gear drive, the stress applied to the gear teeth as they engage with one another during normal operation causes the metal to bend or deform repeatedly. This deformation is normally not severe enough to be visible or measurable but can eventually cause cracks to form, as shown in Figure 1i. Fatigue cracking usually culminates with the tooth fracturing when the metal can no longer support the load.

Uneven gear-tooth surfaces or shock loads can create local areas of high stress at the gear-tooth surface. This can lead to surface fatigue failures such as initial pitting, as shown in Figure 1j, and spalling, as shown in Figure 1k. Spalling is similar to pitting, but material continues to break away from the edges of the pits, forming large, irregular, interconnected voids in the tooth surface.

Excessive wear or disfiguration. Excessive wear or disfiguration of gear teeth can be caused by insufficient lubrication, abrasive contamination, or overloading the gear drive. If your drive's lubricating oil is present and free of contaminants, ensure that the gears were designed to handle your application's load requirements. If not, work with your supplier to find a suitable replacement drive that uses case-hardened gears, gears made from a harder alloy, or gears with a greater face width. You can also consider redesigning the drive to increase its load capacity.

Gear-tooth breakage. Premature gear-tooth breakage, as shown in Figure 1l, can be caused by contaminants entering the gear drive, overload, or shock load. If outside contamination has caused the breakage, remove the contamination and cover the drive to prevent further damage. If the breakage was caused by overload or shock load and eliminating the overload or shock load condition isn't possible, consider upgrading the drive. You can replace the drive with one that uses wider-faced gears or, if your drive's gears use a 14.5-degree pressure angle, switch to a drive with gears that use a 20-degree pressure

angle. Pressure angle is a measurement that has to do with the steepness of the tooth profile, and the two standard angles are 14.5 and 20 degrees. A tooth with a 20-degree pressure angle is less steep than a tooth with a 14.5-degree pressure angle, which means that the 20-degree tooth is wider at its base and is able to handle higher loads.

Excessive drive noise. Excessive drive noise can also help you identify abnormal or premature gear wear. Excessive drive noise is most commonly caused by improper backlash but can also be caused by a misaligned drive or excessive drive speed. If your gear drive is making excessive noise, ensure that the gears are rated for your drive's operating speed. Check the drive for worn gears and replace as necessary, and then ensure that all gears are aligned and set to the proper backlash. **PBE**

Reference

1. See OSHA 29 CFR standard 1910.147, *The Control of Hazardous Energy (Lockout/Tagout)*, available at www.osha.gov.

For further reading

Find more information on this topic in articles listed under "Mechanical conveying components" and "Drives" in *Powder and Bulk Engineering's* article index in the December 2015 issue or the Article Archive on PBE's website, www.powderbulk.com. (All articles listed in the archive are available for free download to registered users.)

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